CONFERENCE ON PRODUCTION PLANNING AND CONTROL

Introduction by Chairman of Mechanical Engineering EDC

At the highly successful EDC Conference Audco Ltd.* presented a detailed case study based on their experience to a small high-level audience. The EDC and the NEDO are greatly indebted to Mr. E. B. Leach, Chairman of the Company, and his fellow directors, Mr. G. M. Ranson and Mr. B. H. Toms, who presented the two valuable papers which are reproduced below.

The EDC attaches the greatest importance to improvements in production planning and control because it has received ample evidence that many engineering companies hold excessive stocks in relation to their sales, and that delivery performance is often poor, with long deliveries and still worse, broken promises. This leads to a cascade effect and a maddening proliferation of delays which, in turn, opens the door wide to foreign imports. Recent events underline the threat to economic growth resulting from a weak balance of payments.

The EDC considers that for progress to be made it is essential for top management to believe that stock reduction, better and more reliable deliveries, and increased productivity are necessary and to have confidence that they can be achieved. If top management have this faith and determination the difficulties and frustrations will be overcome and real progress made.

When Audco began to consider their problems they realised that, although already a successful company, they had excessive stocks, indifferent delivery performance and many inter-departmental frustrations and that the problems could only be successfully overcome by a co-ordinated company effort, involving all the activities of every department. They have found that a total integrated approach is necessary to "plan the work", from incoming orders or sales forecasts, right through the departments of the company to final despatch, and then to "work the plan", leaving management to deal with those problems which fail to meet the plan. Sales, accounts, purchasing, etc., as well as production, are departments involved in the total plan; while management techniques such as work study, production engineering, cellular grouping of machines, job evaluation, production control, etc., also make their contribution to the overall plan. Audco have steadily pursued this policy: they have looked at the totality of their operations and framed their plans accordingly. Having made the plans all departments endeavour to fulfil them. The remarkable results achieved are summarised below.

Sales	Up 32%
Stocks	Down 44%
Stock/Sales ratio	Down from 52% to 25%
Manufacturing time	Down from 12 to 4 weeks
Overdue Orders	Down from 6 weeks to under 1 week
Despatches/Employee	Up, about 50%
Capital Investment	Cost recovered 4 times by stock reduction alone

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*Audco Ltd., a member of the Serck Group, are manufacturers of taper plug valves for the process industries. Present output is of the order of £4 m. and total employment is about 1,000.

The EDC believes that exhortation is not very effective but that successful examples of applying this basic policy should help to lead other companies to consider the scope for similar improvements to the benefit of sales, profits and productivity. Company boards should sit back and look at their business and study the philosophies and attitudes from order placing to despatch and break down every departmental barrier to an overall plan by "planning the work" throughout and then "working the plan". The incorporation of improved management techniques within the overall plan can make an important contribution to higher efficiency and the more effective use of labour and capital.

In discussion, some speakers stressed the importance of maximum machine loading and questioned Audco's policy of deliberately planning a margin of capacity. Some contributors doubted whether many managements could themselves conceive the basic planning procedures and thought consultants should be employed. Other speakers said their problems differed from those of Audco, e.g. spares were a more serious problem, the market was more fragmented, etc.

The reply of Audco on machine loading was interesting and follows from their insistence on considering the totality of operations. In their view it is better to have £150,000 of machine tools standing idle than £500,000 of stock, i.e. optimum machine loading can only be evaluated in relation to all the operating variables. As far as consultants were concerned Audco had rejected this solution: they felt that management must lead and steer all reorganisation: they must have confidence that what is proposed is right and then see it through and work it afterwards. In particular they felt imposed solutions frequently led to management resistance, which is lacking with self-generated plans.

The argument that other companies face somewhat different problems is valid but there is no suggestion that the Audco solution should be applied uncritically. What is emphasised is that similar principles apply to a wide range of engineering companies; the differences lie in the detailed application of these principles.

The first requirement is the determination of the company Board to improve performance and to overcome departmental resistance to change by taking a global view of operations. Once a firm decision is taken that there is a problem and there is confidence that it can be solved, the company must find its own solution.

The EDC believes that the personal involvement of top management in this total approach to planning the company activities can bring marked benefit to the companies in mechanical engineering with significant improvements in sales, profits and productivity and the service they render to their customers. The EDC intends to organise, in association with the Institution of Production Engineers, a series of high-level regional meetings based on informal and detailed discussion of case studies provided by various types of engineering companies.

D. A. C. DEWDNEY,
Chairman.

Operating Your Business

G. M. Ranaon, Managing Director, Audco Ltd.

This story tells briefly and in simple language the steps that were taken to raise what was already acknowledged to be a normal, efficient, good profit making company to a new level of efficiency capable of meeting an expanding market and the challenge of world competition.

The capital investment of the plan, which took about four years to achieve, has been recovered four times by stock reduction alone and the resultant operation has enabled the company to move forward into planned expansion.

Most of the principles and techniques have long been propagated through many media – we have put them into practice.

Stock reduction was not dealt with in isolation, nor could it be; it was one benefit resulting from a full investigation and reorganisation of the philosophy and methods of operating a whole factory. Tremendous benefits have been gained, but these involved long periods of thought, consultation and effort by many people led by a management convinced that there was an important job to be done.

Over the period reviewed, here are some worthwhile results:

Sales up 32%
Stocks down £550,000, or 44%
Stocks/annual sales ratio down from 52% to 25%
Average manufacturing time down from 12 to 4 weeks
Overdue orders down from 6 weeks output to under one week
Despatches per employee p.a. up from £2,220 to £3,105
Average earnings per employee up from £715 p.a. to £897.

The task proved to be a very big one but the result has more than justified the effort.

Operating your business

We believe the purpose of getting together today is because certain problems exist within our organisations.

Together we may analyse these problems by recounting to you our practical and factual experience of facing up to our problems and setting about means to resolving them.

The first healthy sign is the recognition of problems and thereafter being resolved to find solutions to them.

We believe the problems facing us are common throughout industry and we will endeavour to stimulate your interest and appetite by posing some questions stating some simple objectives, and lead on from them.

It can be taken that the companies represented here have full order books, indeed overfull relative to the ability to satisfy them, not necessarily by volume but by promised time.

Failure to satisfy a delivery promise is becoming more and more the charge levelled against British industry, particularly in the export field, and the more serious when our record is compared with overseas competitors.

These charges are equally valid for home sales which, if corrected, can only result in increasing our wealth and consequently the national wealth.

Therefore, the real and ultimate objective is: *To deliver products on time and arrange the operation so that the time required is truly the minimum necessary.*

To attain this objective it is necessary to take a cold hard look at your total operation, because so often it is believed that by introducing a first class production control system the problem is solved, equally a first class production set-up in itself provides the solution, and the more popular belief that the installation of a computer provides the millenium. How wrong!

The *total operation* has to be studied and an integrated plan from the receipt of an order to the despatch of a product formulated and acted upon with determination and drive.

Invariably it will be found that far, far too much of the control of the business is vested in people who are departmentalised and generally acting in isolation, without a semblance of co-ordination, each keeping its own records – often duplicated elsewhere, or not complete with all relevant information.

This may sound a sweeping statement but we feel confident that analysis will show this state of affairs.

With all the best will and intention, these people believe they are doing the best possible job and in the climate of traditional operation of the business do not stop and question the efficiency and overall results of their own or the company performance. Moreover, difficulties are readily laid at the door of everyone but themselves, and you cannot prove otherwise!

In our case, we had problems – and have solved many of them – but only after travelling along many blind alleys from which we as quickly as possible retreated. The purpose is to tell the story to stimulate and encourage you to look at your business and see if similar problems exist, and if our solutions can be of help.

Serious consideration had therefore to be given to a truly co-ordinated operation and effort, and the isolationist personal and departmental traditions swept aside.

How, therefore, do we begin? We can only begin by the people right at the top recognising the problems, and being resolved and determined to solve them.

We are telling this story to you because you are the people at the top, and it is from people like us the initiative must come, since the progress and success of our business depends wholly on us, as executive management.

Get together and ask some pertinent questions, the answers to which will result in formulating some worthwhile objectives. Don't be afraid to tread on a corn or two by expressing the truth of the situation and resolve to come up with good and honest answers despite argument.

These are the questions which were pertinent to our problems.

1 Do you maintain your delivery promises?
2 Are your delivery times competitive and can they be improved?
3 Is your overdue value to customers excessive?
4 What is the basis of computing delivery dates?
Is it by hunch – practice or measurement?
5 Do you quote and receive orders against known false delivery dates?
6 Can the time taken from order stage to product despatch be measured by available information and data?
7 Do you carry excessive stocks relative to sales?

8 Have you excessive work in progress?
9 Do you maintain tight control over material issues, stock records, goods receiving, and despatches?
10 Is your work-on-hand level too high?
11 Is the output requirement measured relative to immediate and growth requirements?
12 What is your production philosophy and practice – batch or flow?
13 Do you make what you want when you want it, or create buffer stocks in the hope they will contain the correct things when wanted.
14 Are all your products profitable?
15 Are you making an excessive variety of products?
16 Does the inclusion of a substantial volume of specials tend to interfere with smooth running?
17 Is each product and component identifiable and expressed by code?
18 Can your code be used by high speed mechanised or electronic data processing?
19 Do you operate an up-to-date payments system, based on measurement?

The foregoing is a fairly formidable list of questions, but, only satisfactory answers to these questions, and maybe many others relative to your business, will form the basis for a plan, leading up to the ultimate and real objective.

Our tasks were, therefore, as follows:

1 To create facilities to provide accurate information for delivery dates and maintain them.
2 To provide a coded system for identification of all parts, assemblies and products.
3 To create facilities to provide the shortest throughput time from receipt of order to despatch.
4 To reduce stocks and work in progress to a minimum commensurate with efficient operation.
5 To examine the product line, eliminate where necessary, and rationalise as far as possible to provide an acceptable product line.
6 To base the whole activity on measurement in order that facts can be used for computations.
7 To institute tight controls and disciplines on all material movements and recording.
8 To create materials supplier relationship which ensures reliability.

This last point is important, since in our case our suppliers are now well aware that our demands are real and truthful, and false delivery promises from them can seriously upset our operation. Accordingly a close and honest relationship has been created.

With these objectives the real task begins:

'Planning and implementation'

We had already undertaken to use a coded system to identify materials in all stages, raw, machined pieces and products, and were able to apply the coding to punched cards for automatic data processing, but in addition all records, drawings, parts lists, stores cards, etc., had to be changed and brought in line with the new coding.

In the case of drawings, one drawing invariably contained details from which several versions of the piece could be made, and accordingly new drawings had to be made for each individual piece with its appropriate number. Many pieces were made by using a master drawing and reference to several other drawings to obtain the complete requirement. This led to errors and incorrect pieces. The principle of one drawing per piece made instructions simple and errors almost eliminated.

The punched card stack for each product enabled all incoming orders to be exploded into piece parts – raw and finished – and aggregated into lists of like part requirements for buying, loading, and stock input and output records.

This brief glimpse into some semblance of order leads into the production control story, which will be told separately.

Having therefore created a base for all our activity, we move on.

We realised that if we were to take advantage of a production control system which was able to state accurate demand with speed and effectiveness, we had to create a production facility to match this speed and effectiveness.

Accordingly an intensive study was made of our philosophy and techniques of production and related activities.

A team of six Work Study Engineers was engaged who, uninhibited by former practices and traditions, were able to apply themselves with fresh minds and conform to the requirements of the plan.

A careful study of the technical and management requirements was also reviewed and the need to strengthen this area became apparent.

Appointments were made after very careful selection, not only for technical and management experience, but for forward looking attitudes and the will and zest to pioneer the implementation of modern techniques, despite the formidable task posed to them.

These new personnel together with leading existing personnel, formed an executive team which created a detailed plan and induction programme carefully time-scaled for feasibility, without loss of production and disturbance of the business generally.

This executive team imbued by a sense of real purpose and convinced of the fruits of the exercise, applied themselves with determination and skill in the face of severe resistance by those so long entrenched in the previous practices, and fear that changes would react against their personal interests and prestige.

In fact the most difficult part of the plan and its implementation was the resistance it had to overcome, with almost every argument used against it. Indeed, practical resistance through non-co-operation and blocking was used, but the team's tenacity and patience prevailed.

Evidence of improved attitudes followed completion of early parts of the plan, and resistance diminished proportional to the completion of the plan.

Today a reversion to the former way of life would lead to an exodus from the company, as life has truly been made that much more easy.

The team having completed a detailed plan on paper together with material for induction to all levels, the programme was begun.

The principle of production was conventional – groups of like machines arranged throughout the machine shops, each manned and requiring to be constantly fed to keep each employed.

Small wonder that under this principle large volumes of parts were machined, very many of which would not be required for lengthy periods, consequently building up large volumes of work in progress and unwanted parts.

Moreover, the volume of work in progress and excessive materials movements produced a comparatively inefficient and costly operation.

Volume was being achieved at a value generally in accordance with requirements but made up of the wrong things. This was further worsened by imbalance of requirements.

It was equally evident that the control of stores was slack, since in order to sustain production on each machine, supervision were able to draw from stores such materials as were necessary for this practice.

Studies and computation had shown the many weaknesses of the principles then employed in the production and related fields; it therefore followed that a complete new look at our production principles had to be undertaken.

A plant layout was made and photographed without the work in progress, which revealed a very poor space utilisation. By far the greater area being used for work in progress and gangways for materials movement.

With the excessive work in progress and piece part stocks removed, it was immediately obvious that the areas available could contain nearly three times the items of plant arranged on the flow line principle.

The new layouts made up with scaled models of standard plant were prepared and use what we call the Cellular Group Production Method. This method is admirably suited to the greater part of our production and although perhaps not directly suited to many other production requirements, its basic philosophy and practice is undeniably suited to most production requirements.

The term 'Cellular Group' means a number of flowline cells of plant disposed alongside conveyors so arranged that piece parts starting at one end are completed at the other end. (*Figure* 1).

Each group was laid down for a specific type of piece part, material and size range, each cell being for a limited size range.

This involved an immense number of method changes in order to balance as near as possible the elemental times of each piece, and many new methods were evolved.

Each cell contains the requisite number of machine tools to deal with the variety of piece parts within the size range.

For example, a cell contains 12 machine tools which is the maximum number required for the most complex piece, five only being required for the simplest piece. Five operators are employed and use all twelve machine tools as required.

The rate of output is generally the number of machine tools used faster than the former principle, and work in progress is virtually eliminated together with most material movement.

It can now be seen that a substantial investment in machine tools, tooling and equipment was undertaken, and in order to operate this principle mobility of labour was essential.

Everyone concerned, including machine operators, were invited to study the model layouts and had explained to them the advantages over the existing principle. They were invited to comment, criticise and make any suggestions for improvement, and many were forthcoming.

At this point it may seem unreal that such enthusiasm and interest should have been displayed by those most directly affected by the change. So, it is as well here to explain that during the induction, mention of a new wages structure was made, based on job evaluation with the real prospect of the company being in a position to improve earnings from the obvious productivity that the plan would provide.

The co-operation from the shop stewards and operatives can only be described as magnificent, and the whole production plan was implemented with a total team spirit.

A new wages structure based on job evaluation was adopted, and with union participation the structure and evaluation of jobs was computed.

The result was nine rates of pay throughout, expressed as an hourly rate, which replaced 93 different rates of pay in one machine shop alone, and at the point of implementation we awarded an average increase of 13/4d. per week.

Coincidental with the major production layout changes, the stores were made secure, bins replaced by pallets, toke boxes, and one-handling devices. This ensured the quick movement of materials and stock recording.

Assembly lines, which were formerly disposed in three areas, were consolidated into one, with consequent rationalisation of personnel and equipment together with much greater labour flexibility.

Methods studies were now concentrated by specialising on piece parts within groups and cells and a spirit of competition between groups and cells resulted in constantly improved performances.

The entire exercise awakened a restlessness which is ever present, to the extent that nothing we do is right and we are constantly seeking new ways.

We had therefore so far achieved a coding system for all our materials, piece parts and products, and with its use a production control procedure was evolved using high speed data processing; a production facility created with all its attendant services closely controlled for materials and movement, and a mobile labour force rewarded by an up to date wages system. In the wake of the foregoing, office functions were simplified and tailored to the overall plan.

Throughout the implementation as near accurate measurement of all production activity had to be carried out, not only for incentive payment, but for realistic work loading, without which no delivery promise can be computed, or planning for increased loadings be undertaken.

What of the attitude of the sales force to all these happenings? It is they of course who can, and do, constantly use their big stick to beat the production people for failing to deliver the goods – and rightly so.

They bear the brunt of confrontation with irate customers, and become very frustrated with conveying false promises knowing only too well they are false.

The relationship between the sales force and the production people was never a happy one – but not now! They, together with all other sections, work as a company and they go forward with confidence and indeed pride that they can offer the truth.

The truth can sometimes be bitter because we will not quote for an order based on a false delivery promise.

Each enquiry of a large and complex character, requires and receives top level treatment and is the subject of a feasibility plan based on as near as possible accurate measurement of drawing time, pattern time, casting time, materials acquisition time, and production and assembly and test times; if they add up to something in excess of what delivery the potential customer requires we state what we can do, no more, no less.

We believe the customer will soon recognise the truth and act accordingly.

It is only fair to point out that the sales force also had a pill or two to swallow. Somehow they tended to lean toward the 'special', and it was not easy to get across the importance of selling the catalogued product line.

The inclusion of special items is a serious drag on any production facility, and should be priced commercially even if this eliminates them. In practice we found it generally eliminated them and only the genuine special is now accepted which is correctly priced.

Induction to the sales force on all aspects of the new operational concept and practice revealed to them the importance of volume and profitability.

Whereas they always felt out on a limb in company affairs, they were now brought in with all other functions to play a co-operative part.

This attitude has unquestionably resulted in a fresh outlook and feeling of responsibility and the drive to increase sales was approached with zest.

If the company is in a position to deliver the goods, and gears itself to cater for increased volume to ensure continuity of this performance, the sales force have a true incentive.

It is only fair to point out that although the foregoing presents a story of achievement, many hard things had to be said and a number of resistors and failures had to be cast aside.

The implementation was pursued not only by reason, persuasion and facts, but by a ruthless determination.

Two redundancies amounting to a total of 105 Works personnel and 50 Staff were dealt with and a firm labour establishment practice set up.

Productivity has surged forward and 3 productivity increases have been awarded across the board to Works and Staff. (*Figures* 2 *and* 3).

In addition, stocks and work in progress relative to sales fell dramatically, and overdue orders are maintained at less than 2% of sales. (*Figure* 4).

The function of Management at all levels became clear and objective. By far the greater energies were formerly deployed, 'fire-fighting' amid the morass of outdated information and insular practices.

The new operation based on logic, measurement and planning, thereby knowing what was required – and when – enabled Management to concentrate on the failures of the plan.

This is 'Management by exception', since concentration was centred on the 5% to 7% not achieved. Moreover, the 5% to 7% not achieved became the beginning of the next work load, and was never allowed to be lost and ultimately tagged on to some future work load.

It must be clear that Management, now able to concentrate on their true functions, turned their energies to forward planning and better practices. Once the principles and philosophies were established they became self-generating, engendering a forward progressive outlook.

One vitally important point which cannot be over-emphasised is the truism that the 'art of perfect management is the art of perfect delegation'.

Anyone who fails to delegate and pass responsibility to those appointed to do a job fails miserably in his own task of management. It equally follows that such delegation can only be to people fitted to accept and carry out their function. Any lesser people should, or indeed must, be removed and the appointments properly filled.

By releasing the energies of people through responsibility which is rightly theirs, and for which they are paid, you will quickly discover the hidden talents and also the deadwood. No company can be efficient by suffering mediocrity at any level and it is the first duty to get this straight.

We are proud of our achievements to date, but look upon them as the spur for even better practices and improved techniques.

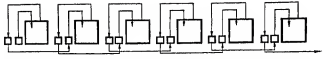
The world is our market, and our consistent performance of more than 50% export is a major part of our endeavour.

Conversely we buy in world markets, and any item of plant and equipment best suited to our needs is purchased wherever its source.

Our immediate target is to arrange our operation so that from the release of a production programme, raw material moves throughout all its changes of state to the finished stores or despatch of a product, without a pause. We are some way there, but there is some way to go yet.

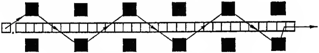
Finally, let us quickly retrace the steps and the results.

1 We used a team of Work Study Engineers to analyse and review our general operation.
2 We centralised all production planning and used data processing machinery. To permit this we had to use a coded system and establish one drawing and one number per part.
3 We set up a high speed production facility backed by disciplined stores control, with consequent low work in progress and stocks.
4 We reduced our throughput time from an average of 12 weeks to under four weeks, and an overdue customer value less than 2% of sales.
5 We introduced job evaluation and labour mobility together with a share of the benefits of increased productivity to all our employees.
6. We provided wide coverage of induction in all the new techniques, and took great care to explain our plans and carry factory opinion with us.
7 We reduced the number of specials largely by pricing them out.
8 We achieved a new-look sales force, based on confidence and co-operation.
9 We achieved a total company outlook based on totally integrated operations.



Conventional Method (Example)

6 elements of 2 mins. each, floor to floor—100 pieces per pallet. Neglecting time taken to transfer pallets and waiting time for forklift truck. 2 × 100 × 6 = 1,200 min.



Cellular Group Method (Example)

1st piece = 12 mins. 99 pieces = 198 mins. Total = 210 mins.

W.I.P. ratio of conventional/cellular 600/100 pieces = 6:1. Taking into account out of balance elements and waiting time for conventional method, total time can be 25% greater. Consequently W.I.P. is 725 pieces.

W.I.P. ratio of conventional to cellular group method is 725 to 100, or 7·25:1.

Figure 1

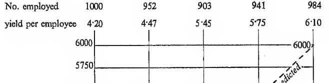


Figure 2—Audco Ltd. Total annual output in tons and yield per employee.

Audco Limited

	Net Despatches	Total Personnel (Average)	Total Wages and Salaries	Despatches per Employee	Av. Income per Employee
	£M		£	£	£
1961/62	2·220	1,001	714,467	2,218	714
1962/63	2·184	952	705,911	2,294	742
1963/64	2·585	903	752,121	2,863	833
1964/65*	2·922	941	843,671	3,105	897
1965/66†	3·152	984	947,962	3,203	963

*1964/65—12 months to 31.7.65.
†1965/66—At annual rate based on the first half-year.

Figure 3

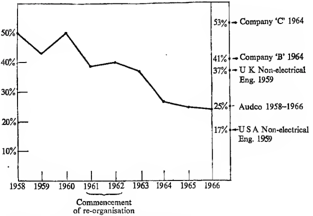


Figure 4. *Stock/Sales ratios. Audco over* 8 *years.*
Audco and companies 'B' and 'C' are in the same sector of industry, partly competitive and each employs around 1,000 people and similar regarding product varieties, batch sizes.

Production Control and Related Matters

B. H. Toms, Director, Audco Ltd.

You already have the overall background of our company into which what I am going to say on production planning and control will fit so there is no need for anything much by way of introduction from me. But I must just emphasize or re-emphasize three points.

Firstly, the vital necessity of getting all the people in the various departments thinking in the same manner. This does not, of course, mean thinking the same. That would be fatal to a properly balanced solution.

Secondly, also connected with people, the essential need to break down inter-departmental barriers and to get the business working as a co-ordinated whole instead of a number of separate departments, probably with divergent aims.

Thirdly, we have aimed at a few simple and straightforward principles backed up by a well-thought out and tightly applied control system as being a better way to improve things than trying to use sophisticated techniques which may well have their theoretical advantages but which cannot be adequately exploited because of the absence of a proper mechanism for their practical application. Simplicity is hard to achieve and I would go so far as to say that a simple scheme with just a few rules which all can understand is probably more difficult to design than one which has a complicated although more ideal set of rules with their attendant list of exceptions. I will try and follow the same rules here and keep things simple. If this results in over-simplification you are, I am sure, well aware that there is a bit more to things than a few apt phrases.

The life we led

Audco's position a few years ago was that we didn't seem to be too bad at overall long-term planning; generally speaking we were producing and selling the volume of goods planned and stocks went up and down broadly as desired. Yet we were not good enough at meeting promised delivery dates and stocks didn't at any moment appear to contain quite the right mixture of items, and there was always said to be more stocks than were necessary to sustain the business.

The paper-work was voluminous but suspect. The Accounts Department tried to keep accurate stock accounts but they were never right when a physical stock-taking was made. Buying Department seemed to be working hard, receiving a continuous flow of hand-written requisitions (a number of which demanded impossible delivery dates), and quite large volumes of amendments to requisitions and amendments to those, also urgent chase notes, or some such documents, urging delivery of materials they had not always ordered.

The life of the Progress Department in the factory seemed to consist of trying to get done in one day what should have been allowed several weeks; pulling materials just arrived out on to the factory floor and rushing them through by pushing everything else on to one side to be sorted out into their respective degrees of urgency at some other time; finding people at certain machines short of work and ferreting around in the stores to find some suitable material for them to work on; explaining at frequent meetings why this, that or the other had not been made or why too much of something had been made; attending urgently-called meetings to deal with some crisis which had arisen because everyone had been busy dealing with the previous crisis, and so on.

What about Sales Department? Their time seemed to be fully occupied attending crisis and other meetings, keeping up an endless stream of paper called progress reports which were sent to the factory to have recorded on them the latest guess at a revised delivery date; writing memos urging that those orders which had been given an impossible delivery date in the first place should be 'expedited' by all means possible and impossible; and, of course, keeping up the flow of new orders some of which they knew would cause trouble unless continuously 'progressed'.

In brief, a picture of people working hard and doing the best they could but, if they were honest, without really being sure what they should be doing, or not sure that what they were doing was right for *that* time. Surely, we said, there must be a better way.

The crux of the problem

The crux of the problem was the absence of a comprehensive overall master plan into which all details fitted; from which proper decisions on changes and extensions to the plan could be made; and through which the activities of all departments would be welded together. We were short of the administrative machinery for:

(a) exploding the production plan into sufficient details so that all would know what they had to do and when.

(b) doing this quickly enough and at frequent intervals so that it would be as up to date as possible, and

(c) ensuring that work done by various departments was always in accordance with the latest issue of the master plan.

We needed a reconstituted and more effective control centre for the company.

Sorting out objectives

There are of course a number of desirable objectives in any manufacturing business but quite often some of them are conflicting one with another. For example, in the type of business we are now concerned with it is almost impossible to achieve at the same time quick deliveries, full utilisation of plant and low stocks.

The first thing that has to be done is to look at the various objectives and be precise about them. This sounds elementary but it is often by-passed. Also these objectives must be placed in what is considered to be their relative order of importance for the firm so as not to be attempting several at once which may be in conflict and would pull the firm in several directions at once.

In our case we put at the top of the list the achievement of promised delivery dates with the prevailing throughput time, followed by a shortening of the throughput time. In each case with no loss of efficiency on other counts. In other words we said we would 'make what we wanted when it was wanted', and then do it faster and be as efficient if not more in terms of profit.

Speed of reaction

From afar a factory making a specified range of products may appear to be leading a fairly regular and routine sort of existence but under the surface it is, or should be if properly controlled, in a constant state of change because it should be all the time correcting for the continual introduction of new or different factors.

One has to accept that if a factory is not equipped with a sensitive and quick acting nervous system it is bound to be reacting today to what it should have reacted to some while ago. If not so equipped the production process becomes very sluggish, and, in order to have a good chance of being in possession of more or less the right items at the right time without knowing with accuracy what is really needed and, more important, when it is needed, the factory surrounds itself with comfortable quantities of materials at each stage and allows itself comfortable amounts of time to perform its various tasks so that it won't be so likely to get caught short when it finds out what it really should have done.

This point on the 'speed of reaction' of a factory is, in my opinion, a most important aspect of the problem. But let me make something clear. It is quite simple to have a quick reaction time for this, that or the other product on its own. Someone in a position to do so simply bangs on the table and insists that the particular orders under the spotlight at that moment 'had better be out on time or else'. They usually are, but undoubtedly at the expense of other orders which will themselves be labelled 'top-super-high priority-urgent', or whatever it is, in due course. I don't mean this sort of thing but a method of operating which allows methodical re-calculations to be made right up to the last moment to show the real situation and at the same time maintains close control.

Principles

Turning now to the present situation at Audco there are a number of principles which have evolved and which we are now following and I shall deal with some of the more important ones rather than attempt to describe even in outline the whole operating scheme.

1 Organisational aspect

Production control was originally a department under the Works Manager with the orthodox responsibilities of giving delivery dates, making out production programmes, requisitioning materials on buying, loading the foundry and generally progressing the work through into the finished stores.

We regrouped these activities and some others by forming a new planning function centred around materials management, responsible to neither Sales nor the Works, with responsibility, in broad terms, of formulating the forward production programmes and acquiring the necessary materials. As portions of the programme become due for execution the final details are settled and a carefully prepared parcel of work is passed to the factory for immediate action.

This Materials Management function, comprising the programming department itself, together with purchasing, and stock control at all stages, was placed under the Finance Director to assist in bringing to bear a coldly-calculating approach, unaffected by emotion and the subconscious bias of particular departments, and making decisions based on facts. Indeed the necessity to face facts after they had been collected (which was sometimes a hard task in itself), was a great help.

Figure 6 illustrates the present organisation.

2 Material control versus work centre loading

If things are going wrong is it that the materials are generally there on time but work on the materials is not well organised? Or is it that production is handled well but is continuously handicapped by shortages of materials? I don't think you can ever get a factual answer but I do think it is essential to assess the relative importance of material control as against work centre loading. Which would have the greater impact if improved? Co-ordination between the material control function and the work loading function is, of course, vital and its absence is a frequent cause of trouble but I am sure it is better to co-ordinate them by making one the dominant partner, as it were, the other, the junior partner, being expected to be sufficiently flexible to keep in step.

We concentrated on accuracy of material planning and control and used quite simple work load measuring devices to begin with.

I would add that it is impressive to see the amount of work a shop can get through, irrespective of whether the work load is nicely balanced out or not, if it is given a square deal by having all the required materials and parts available when the starting gun is fired and is then left alone to concentrate all its energies on getting the job done in the shortest possible time.

3 Control cycle

In the absence of very sophisticated control devices it is necessary to stop and re-plan comprehensively at intervals of time, then to operate sufficient of the plan to last until the next reassessment when the cycle is repeated. *Figure* 7 will help to illustrate this.

It is important to choose the correct time for the control period by weighing the advantages and disadvantages of various times. The shorter the cycle time the more frequent the reviews are done and thus the more flexible the system becomes in accommodating changes and the tighter the control becomes – because of tbe small size of the parcels of work issued. Against this must be set the increasing cost of processing and reviewing the information as the cycle time shortens plus the increasing complexity in making up balanced parcels of work as their size is reduced. We chose a cycle time of two weeks. You must bear in mind that the production planning re-organisation was not being done in isolation. Various changes had taken place in the factory so that it was able to accept short-term programmes instead of bowing down before the god of long-runs.

4 Division of programme into provisionel part and actual manufacturing part

All ordering for production is in the form of precise orders specifying the end product, the quantity and the date, both for forecast requirements and for firm customer orders. There is no provision for an instruction to 'make about 50 a month until I tell you to stop'. These orders are classified as 'provisional' orders or 'firm manufacturing' orders. A production order will always enter the programme as a provisional order and has to fulfil a number of requirements before it can be converted to a firm manufacturing order. Whilst an order is in the provisional part of the programme it will be having its materials acquired and may be amended in various ways.

Firm manufacturing orders are issued to the factory in a batch every two weeks in accordance with the control cycle and this re-assessment and the issuing of a further carefully made up parcel of work is known as 'firming up' the programme. This is quite a good name because it correctly suggests that that part which has been 'firmed up' and issued cannot be subject to further change. It is not, however, just a matter of pulling out all the orders due for completion in, say, June and calling that the firm programme for June.

The firm orders consist of a selection of the provisional orders bearing a date or batch number of the period to be firmed up and which comply with the following conditions:

(a) They are either actual customers' orders due for manufacture to commence at that time or definite needs for finished stocks in the light of the situation at that time.

(b) A complete set of the required raw materials for each order must be physically present in stock at the time of making up the programme.

(c) The total load of work imposed on the various machining and assembly load centres must be measured so as to be the right amount to last until the issue of the next firm programme – i.e. two weeks' work. The whole factory is kept in balance by issuing the same amount of work to each load centre. We do not allow some sections to be loaded up with several months' work and others with just a few days. This does not mean that the capacities of the various manufacturing groups stay constant. There has been developed a considerable flexibility in switching labour so the loads can be varied to quite a large extent to accommodate the inevitable fluctuations in requirements of products. But we do not allow the manufacture of parts not immediately needed for the assembly of finished products just to keep machines running. The load will always absorb the manpower available but not always in their customary places.

The effect of such a routine for issuing a prepared load of work at regular intervals, with all the materials available, and not subject to amendment after issue has a tonic effect. The factory is given a chance to plan its work in advance and clear it with maximum speed, and the frustration and disrupting effect of continuous alteration and injection of extra items of work is removed.

A decision is made on each provisional order not made firm for one reason or another – it may be cancelled, re-dated, split, etc., the material control system automatically re-allocating the materials. *Figures* 7 and 8 will assist in demonstrating this cycle of events.

5 Manufacturing principles

The manufacturing programme consists of a piece part machining programme and an assembly programme. Foundry production is dealt with as part of the material ordering procedure rather than as part of the actual valve manufacturing process.

There are three principles associated with manufacturing:

(a) The parts machining programme is restricted to those quantities of parts required to make the items on the corresponding assembly programme. The holding of stocks of those components produced in the machine shops is not part of the plan. Allowance is, of course, made for anticipated scrap and surpluses do arise when scrap allowances are not required and such surpluses are mopped up automatically in the system.

(b) There is, with a few specific exceptions, a standard time for machining and for assembling all products irrespective of their type even though the actual operation times vary widely over the range of products. This has proved to be a very useful device which, besides being simple, substantially assists in establishing in peoples' minds that sense of orderliness, regularity and clarity so fundamental to good control systems. Five weeks is allowed from the time of issue of each programme for all raw materials to have been drawn from stores, piece parts machined and the finished products assembled and delivered to the finished stores. The sequence in which products are completed is not predetermined, planning and control of day to day work is left to the Production Manager, the only target set being that the whole programme shall be completed within the five weeks. This detailed planning is done so that tool changes and related factors are minimised. The former manufacturing time was close on three months as an average over all products. We are not satisfied with the present time and the next phase of development will probe ways of reducing this further, possibly by more scientific techniques for determining the optimum sequence of work or by changing the time of the whole control cycle from two weeks to, say, one week.

(c) Issue of materials only as properly authorised by the programme. None of the works people including the Works Manager, can authorise material issues.

The data processing technique and system

I would now like to turn to some points concerning what I shall call the 'information machine' which supplies accurate and up to date facts at regular intervals to enable all these various tasks to be performed and ensures co-ordination of the various elements of the plan to the whole plan.

It is based on punched cards and works in a fairly orthodox way for a production control system based on electronic data processing with, naturally, some tailoring to meet our specific needs and to match our approach. If one is thinking of computers then one could simply substitute the words 'magnetic tape file' for 'punched card file'.

The materials used are divided into the following four categories as *Figure* 5 shows:

1 Foundry-made castings.
2 Purchased Raw Materials.
3 Manufactured Finished Parts.
4 Purchased Finished Parts.

For every part number there is a *master punched card* containing the category code and a description of the item, together with other information appropriate to the category. For example, the card for a manufactured finished part contains the part number of the raw material from which it is made, and, for a unit of the part, the quantity off of raw materials; the machine group used to make the part; the standard cost of the part for raw material and for machining; and so on as required.

For every finished product there is a *master bill of materials* (or parts list) consisting of a set of punched cards specifying the quantities of each finished part required to make one of the product.

In addition there are files of punched cards – continuously updated – covering the following:

1 The record of all *stocks* of raw materials and finished parts.

2 *Foundry production* programme containing details of all castings on order on the foundry, the week number in which they are scheduled for production, and figures giving the load factor.

3 *Purchase orders* outstanding, containing a record of all purchase orders placed with suppliers, the agreed week number of delivery, supplier code, etc.

4 Authorised *raw material issues outstanding*, containing all those items on the

current machining programme for which the raw materials have not at that moment been issued, with the planned week of issue.

5 *Finish machining programme*, containing a record of all items on the current machining programme which have not been cleared to finished parts store, the week number due for completion, and various statistical information relating to the load.

6 '*Requirements*' of finished parts for assembly, obtained through the use of the master bills of materials, also containing the week number in which they will be required, and continually synchronized with the assembly programme.

7 The *Assembly Programme* itself, containing the latest forecasts for replenishments of stocks of finished products over the next four to five months, plus firm orders for valves not normally kept in stock.

Every two weeks the whole of the above information relating to rough and finished parts is sorted to categories and to part numbers and the whole material flow programme is rebalanced on the data processing equipment.

In the case of the category covering manufactured finished parts, for example, the aggregated quantity of each part number required for the assembly programme in each week ahead is adjusted by stocks of that part currently held in the finished parts store and by quantities currently being machined and the net requirement is converted to raw materials from information in the master data cards to give the revised schedule of raw material requirements. This schedule, besides being a completely up to date record of the whole of the future requirements of raw materials, showing the weeks in which the various quantities will be required, contains details of the load of work which will fall on all the various machine groups in each future week, as far as the programme is taken.

For purchased finished parts the aggregated requirements per week for assembly are compared with stocks and with the purchasing programme to show what additional materials must be purchased and when, or which orders must be cut down or the date of delivery brought forward or retarded.

For the two raw material categories the schedule of raw material requirements just created is used and is adjusted by raw material issues outstanding for the firm machining programmes, and by stocks in the raw material store.

In the case of foundry made castings a new forward foundry programme is produced automatically after adjustment for items already on order on the foundry. This forward programme, in addition to showing the quantities of the various castings required in their respective weeks, shows what the load represents as numbers of moulding boxes per moulding machine per week ahead for the length of the programme.

In the case of purchased raw materials the comparison of net raw material requirement is with the pre-existing purchasing programme for that category which is then brought into line by additional orders, or by cutting down quantities or changing dates of delivery or whatever is required.

Examination of the output of these fortnightly processing runs is the established method of ordering materials. In this way, each part is comprehensively reviewed once every two weeks in the light of the latest information consolidating and summarising additional and amended requirements and incorporating all other changes which may have taken place relating to that item since the previous report.

For this reason, this method of control allows a very great degree of flexibility in changing production programmes to meet changes in market conditions.

A variety of information comes out almost as a by-product of the various data processing runs in addition to the above. Examples are:

1 Tabulation of purchase orders outstanding per supplier. These are sent to suppliers periodically for confirmation that their own records are in agreement and that the deliveries will be made on time.

2 All stock movements every two weeks with value of receipts, issues and balances per item and in total. In the case of receipts by the finished parts store from the machine shops the standard value of labour and of overheads of completed work is also produced for cost accounting.

3 Value at standard cost of the programme of weekly deliveries of material from suppliers, to assist in forecasting and controlling stock levels.

And a number of others.

Before leaving the systems aspect I would like to put to you how we view computers in relation to production control.

We have had punched cards equipment for around ten years but it is only recently that we have decided that further development will necessitate a computer proper.

Hitherto we decided what was wanted at each stage and then found, with a little ingenuity, that the associated data processing could be handled without a computer. After all the problems are only rarely associated with the equipment itself and its limitations, they are nearly always found in matters of organisation and problem definition (i.e. knowing precisely what you want to do) and in getting your raw data to the processing medium accurately, complete and on time.

Summary

1 Since actual manufacture is not authorised until the last moment there is great *flexibility* in amending plans to meet the real needs of the moment.

2 Actual manufacture consists of releasing balanced sets of raw materials to the factory at frequent intervals for conversion to finished products in the shortest possible time. The decks are kept 'cleared for action' in the factory and effort is only expended on the things that are wanted *now*. Materials are held in their most flexible and cheapest form until the last moment and work-in-progress is kept to a minimum.

3 Planned and controlled by dividing the activity into *Plan the Work* and *Work the Plan* sectors; by this means planners are kept planning and doers are kept doing, both concentrating on the work they are best at.

4 The whole thing relies on a central data processing system which repeatedly explodes the master plan into details for all departments and regularly monitors performance. The plan itself is continuously modified as a result of the latest customer demands and to correct shortfalls in performance.

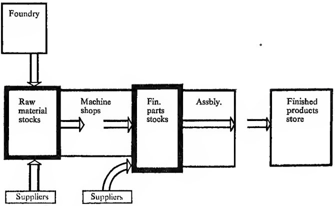


Figure 5: Material flow routes and control sectors

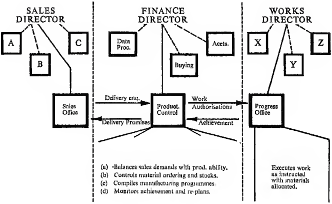

SALES DIRECTOR
A
B
C
Sales Office
FINANCE DIRECTOR
Data Proc.
Buying
Accts.
Product. Control
Delivery enq.
Delivery Promises
Work Authorisations
Achievement
WORKS DIRECTOR
X
Y
Z
Progress Office
(a) Balances sales demands with prod. ability.
(b) Controls material ordering and stocks.
(c) Compiles manufacturing programmes
(d) Monitors achievement and re-plans.
Executes work as instructed with materials allocated.

Figure 6: Organisation

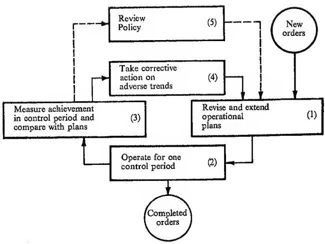

Review Policy (5)
New orders
Take corrective action on adverse trends (4)
Measure achievement in control period and compare with plans (3)
Revise and extend operational plans (1)
Operate for one control period (2)
Completed orders

Figure 7: Control cycle in outline

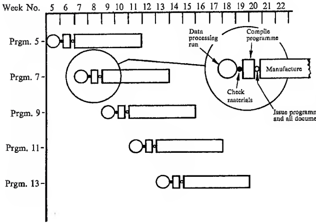


Figure 8: Cycle of events in programming

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